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# A Factorial Study of Emotionality in the Dog

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Psychological Monographs: General and Applied

# A Factorial Study of Emotionality in the Dog[1]

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## I. Introduction

FACTOR theory is fast assuming a central position as an important and fruitful approach in the study of behavior. While the factorial methods have been extensively applied in human testing, particularly in intelligence testing (92), the general applicability of the methods to other domains in a variety of scientific fields has not been sufficiently recognized. The methods are particularly valuable in situations which are complex and where interrelationships are difficult to comprehend. Because factorial analyses of behavior identify factors or "functional unities" which might represent underlying mechanisms, the extension of the methods to animal behavior domains is of paramount importance (72). It is not inconceivable that knowledge of factors in animal behavior could provoke research in the direction of trying to understand their psychobiological details. Before this can be begun, however, exploratory work will have to be done in many animal behavior domains, and considerable thought and experimental work will have to be devoted to properly applying the methods to animal behavior. While the general methodology and the general theory are directly applicable, it is to be expected that problems peculiar to comparative and physiological psychology will have to be taken into account. It is the purpose of this study to present the results of a factorial investigation of the emotionality[3] of dogs. This

[1] A modification of a dissertation submitted in 1951 to the Department of Psychology of the University of Chicago in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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[2] This study was made possible by the help and cooperation of many people. While not all who contributed can be identified in this space, certain acknowledgments are in order. First, the writer is deeply grateful to Professor L. L. Thurstone, who was not only the official sponsor of the thesis, but was also a very active participant in the coordination and completion of the project, as well as the source of much of whatever inspiration went into it. The thesis profited by his counsel and guidance. Second, the writer is indebted to Dr. J. P. Scott, Chairman, Division of Behavior Studies, Roscoe B. Jackson Memorial Laboratory, Bar Harbor Maine, for his splendid and complete cooperation in guiding and encouraging the development of this particular project in his laboratory. Third, the writer is indebted to Professor Ward Halstead and Professor W. D. Neff, Committee Members, who have carefully aided in the improvement of the dissertation. The writer is also indebted to the Jackson Laboratory and its founder and director, Dr. C. C. Little, since the project could not have been initiated without the availability of the Laboratory's staff, data, and facilities, nor could it have been completed had I not received a generous predoctoral fellowship during the year 1948-49. Finally, an acknowledgment is due my wife, who has not only contributed directly by typing large portions of manuscript, but who has also contributed indirectly by being a patient and understanding partner in a difficult venture.

[3] The word *emotionality* will be arbitrarily used to cover the domain in question, that is, social, psychological, and physiological measures of dog

investigation involves no preconceived hypotheses as to the possible factors of emotionality, and is therefore of an exploratory nature. It also includes, as a secondary interest, some attempts to deal with problems of experimental dependence as they are related to test administration problems in animal factorial studies.

Although there has been a wealth of experimental work on the anatomy and physiology of the dog (23), except for the work of German psychologists (25, 75), the extensive research of Pavlov (68) and others on conditioning, and the work of Gantt (37) on experimental neurosis, there has been relatively little scientific work on the psychology and psychophysiology of the dog. The most complete source books on dog psychology are those of Humphrey and Warner (44), Buytendyk (11), and Stockard (88). Less comprehensive experimental reports include those of Ellson (24), Karn (53, 54), Warden (95), and Johnson (51) on mental ability, and Levy (61), James (46, 48), Scott (80), Thorne (89), and the Rosses (69, 70) on social behavior. Fuller's (33) recent study is perhaps the only report which makes a direct attack on what might be called normal emotionality.

## II. The Investigation

### *The Research Program at the Jackson Laboratory*

The Division of Behavior Studies of the Roscoe B. Jackson Memorial Laboratory has been conducting a long-range program on the relation between genetics and social behavior in mammals (especially dogs). The dog project is being carried out in three basic stages: (*a*) test development (social, emotional, mental ability, and physiological aspects of each of these), (*b*) factorial analyses of the basic data, (*c*) genetic analyses. Current plans include doing separate factorial analyses of the social-emotional (emotionality) domain and mental ability domain, and eventually doing an over-all analysis of the two areas combined. Since the data gathering of the first five years has been primarily in the emotionality domain, a factorial study in this area is pertinent at this time.

### *Testing Procedures*

From the time of birth until release from the experimental program, each animal is put through a predetermined series of veterinary (for health purposes), physiological, and psychological tests. This standardized testing program can best be compared with the large scale individual testing which was conducted in Psychomotor Testing in the AAF Aviation Psychology Program (27, 20). Details on standardized procedures, rearing procedures, housing, etc. can be obtained from the Hamilton Station's manual of testing procedures (81) and from Scott's paper on the social development of puppies (80).

### *The Sample*

The sample consists of 53 pedigreed dogs distributed as follows: eight Basenjis (three males), six Beagles (two males), twelve Cocker Spaniels (three males), five Scotch Terriers (two males), eight Shetland Sheep Dogs (two males), fourteen wire-haired fox terriers (eight males). This gives us a total of 20 males and 33 females. These animals were the only ones of several hundred for which complete data were available as of May, 1949.

The fact that there are six different

behavior. The writer's formulation of the problem agrees with that of C. S. Hall (41, p. 385), who states that emotionality "consists of a group of organic, experiential, and expressive reactions and denotes a general upset or excited condition of the animal. Emotionality can be thought of as a trait since animals and men differ in the intensity of emotional reactions displayed. The reader is warned against interpreting emotionality as a thing or faculty. It is merely a convenient concept for describing a complex of factors."

breeds represented in the sample is in agreement with the notion of maximizing individual differences in a factorial study. The original stock from which Jackson Laboratory dogs descended is either registered in the American Kennel Club[4] or is eligible for registration. The laboratory has pedigrees of all the original animals, extending over a minimum of three generations.

*Description of the Test Battery*[5]

Thurstone (91, pp. 55-56) has pointed out that there are two general procedures which can be followed in setting up factorial studies in a given domain. In the first case, one can formulate a hypothesis as to the nature of the underlying processes and set up tests as measures or expressions of these factors. Another procedure simply involves the compiling of a test battery which presumably covers various aspects of the domain in question. In this case, the experimenter has no preconceived notions as to the nature of the factors but hopes that the factorial analysis will lead to several fruitful hypotheses. The tests of this battery were compiled in accordance with the latter procedure. It should be explicitly stated, however, that we entertain no notions that all aspects of the emotionality domain have been covered by the 32 tests of this battery.

Problems of test administration become rather complex in factorial studies of animal behavior. Perhaps the most obvious problem in this regard has to do with the element of time. Aside from the fact that there is much more labor involved in administering a battery of tests to a sample of animal subjects, we also have the concurrent circumstance that it is impossible to administer a large battery of tests to animals in a relatively short period of time.[6] An additional circumstance concerning the 32 variables of this study is that several measures are "repeats" of a given standard measure (e.g., heart rate, reactivity). Since there was no rationale available for deciding at what point in time such measures should be taken, and since this study was set up as an exploratory investigation, it was decided that the procedure of repeating measures was not only in order, but necessary. In summary, the problem before us in compiling this battery of tests to be factorially analyzed was this: How can we cover the emotionality domain as adequately as possible with the tests on hand in such a manner as to avoid incidental common factors due to experimental dependence, and, at the same time, not omit relevant tests? As will be seen in the subsequent discussion on experimental dependence, this is not a simple problem.

---

[4] The American Kennel Club is the official organization in this country for the registration of purebred dogs of all breeds. Over 100 breeds are recognized as purebred and are eligible for registration in the A. K. C.

[5] Variables 1-12 and 20-23 were developed by Dr. J. P. Scott. Variables 13-19 and 24-32 were developed by Dr. J. L. Fuller.

[6] As an example, while it would be possible to administer a similar battery of 32 tests to a human population within a week, the administration of the tests of this battery covered a span of one year for each of the 53 animals of this study. This does not mean, of course, that these particular tests could not be given in less time; if these were the only tests of the total testing program, these particular tests could have been administered within three to six months. The tests of this battery are only a portion of the total testing program. The total testing program includes social, emotional, physiological, mental ability, somatotype, and other measures, all of which are to be administered eventually within the first year of the dog's life. Each of these aspects of test development are in different phases of progress, and all are given at varying points in time during the 365-day testing period. For further details concerning the testing program, see J. P. Scott and J. L. Fuller (81).

Since these tests have been described more fully by their originators in other publications, a detailed, technical description of the 32 variables will not be attempted. However, the tests will be listed by code number and name, followed by a brief description of each.[7]

*1. Vocalizations.* From the time of birth several "weekly observations" are made. One such weekly observation is to record the number of whines or yelps which take place in a one-minute period (while the animal is on the weighing scales). Because vocalizing was most prevalent during the first three weeks of life, it was concluded that this entire period should be included in the test score. The test score is simply the sum of vocalizations which occur in this situation at weeks zero (i.e., at birth), one, two, and three. The higher the score, the greater the number of vocalizations.[8]

*2. Timidity-Confidence I, 3. Timidity-Confidence III, 4. Timidity-Confidence IV.* These measures are also taken during the "weekly observation" sessions. These scores are ratings based on the initial body posture and tail carriage of the pups when placed on the weighing scales. It should be pointed out that only the first tail and body posture are scored. The scoring weights are arbitrarily assigned as follows:

| *Body Posture* | | *Tail Carriage* | |
|---|---|---|---|
| Stand | = 4 | Wag | = 4 |
| Sit | = 3 | Up (normal) | = 3 |
| Crouch | = 2 | Down or Out | = 2 |
| Lie | = 1 | Between Legs | = 1 |

Thus the weights run from one to four, from timid to confident, and the total score for a given session ranges from two to eight. Timidity-Confidence I is the animal's score at the fifth week of testing, the "critical" week in the social development of the pup. The score for Timidity-Confidence III, representing Social Developmental Period 3, the socialization period, is obtained by summing the weekly scores (body posture plus tail carriage is one weekly score) for Weeks 5 through 10. The score for Timidity-Confidence IV, representing Social Developmental Period 4, the juvenile period, is obtained by summing the weekly scores for Weeks 11 through 16.

*5. Inhibition-Activity III, 6. Inhibition-Activity IV.* This observation replaces the vocalizations (see Variable 1) record taken during the "weekly observations" period. That is, for a one-minute period while on the weighing scales, the animals are given mild inhibitory training by the experimenter who keeps his hand near the pup, thereby executing some degree of control over his activity. The activity responses to this mild restraint are rated in one of three categories as follows: active (constant movement =3); partly active (animal moves its feet several times during the period but can be easily weighed = 2); quiet (animal stays in one position for the entire minute = 1). The score for Inhibition-Activity III, representing Period 3, the socialization period in the social development of the pup, is obtained by summing the scores for Weeks 5 through 10. The score for Inhibition-Activity IV, representing Period 4, the juvenile period in the social development of the pup, is obtained by summing the scores for Weeks 11 through 16. Thus, for Variables 5 and 6, the higher the score, the greater the activity (under mild inhibitory training) for Developmental Periods 3 and 4.

*7. Avoidance, 8. Aggressiveness, 9. Et-epimeletic, 10. Attraction.* Each of these measures represents an arbitrarily named category which presumably reflects the nature of the behavior in a series of nine procedures which are parts of a "handling" test. This test is designed to describe the development of the relationship between the dog and "test handlers." The kinds of behavior subsumed under each category, with the arbitrarily assigned weights are indicated below:

A. *Avoidance and fear* (Variable 7)

| | |
|---|---|
| a. Runs away to corner | (3) |
| b. Runs out of reach | (2) |
| c. Gets out of way | (1) |
| d. Lying flat | (3) |
| e. Crouching | (2) |
| f. Sitting | (1) |
| g. Tail between legs | (3) |
| h. Tail down | (2) |
| i. Tail normal position, not wagging | (1) |
| j. Yelping | (3) |
| k. Whining (fear) | (2) |
| l. Grunt (discomfort) | (1) |
| m. Roll on back | (3) |
| n. Roll on side | (2) |
| o. No response | (3) |

[7] The bulk of the descriptions of these variables was obtained from J. P. Scott and J. L. Fuller (81, pp. 16-70). Complete details and sample records concerning these variables can be seen in this manual.

[8] In a previous section where we indicated the breed characteristics of the present sample, it will be noted that eight of the 53 animals, or 15 per cent of the sample, are Basenjis, a barkless breed originally from Central Africa. It should be pointed out that these animals while barkless, are quite capable of other forms of vocalizing, that is, whining, yelping, and growling. Why these animals do not bark is not known. The fact that Basenjis do not bark does not affect the performance on this variable.

B. *Fighting and hunting; mostly playful* (Variable 8)

- a. Biting and chewing (3)
- b. Leaping to touch hand (2)
- c. Pawing (1)
- d. Dashing about (3)
- e. Leaping into air (2)
- f. Panting (1)
- g. Barking (3)
- h. Snarling (3)
- i. Growling (3)

C. *Et-epimeletic; investigative* (Variable 9)

- a. Nosing shoes and clothes (3)
- b. Licking hands (2)
- c. Nosing hands (1)
- d. Whining (begging) (3)
- e. Head or paws in lap (3)
- f. Tail wagging (3)

D. *Attraction* (Variable 10)

- a. Coming toward (3)
- b. Follows immediately and closely (2)
- c. Follows late or at a distance (1)
- d. Has to be called away (3)
- e. Investigates pen (0)

The experimenter and the assistant check the animal's behavior (as indicated above) for each of nine simple handling procedures (given in succession) involving such things as "walk toward," "walk away," "hold out hand," "talk," "pick up," etc. For example, complete instructions for "procedures" zero and one, the first two of the nine procedures, read as follows:

"(0) Bring pup into room, put down at arm's length facing 90 degrees away from you. Stand still for 30 seconds recording all behavior of pup during this time.

"(1) From at least four feet away walk steadily toward puppy as if you were going to walk through him, stopping short if puppy stays in place. Record in appropriate columns. Repeat once."

Weights are given according to the list above for each behavior item; these arbitrary scores are then added for each sub-heading (i.e., for Avoidance, Attraction, etc.). Inspection of the table of arbitrary weights shows that for each variable (i.e., Variables 7, 8, 9, and 10), the higher the score, the greater the amount of the behavior in question. For example, for Variable 10, the higher the score, the greater the amount of adient (i.e., "attraction") behavior.

The "handling" test is given every two weeks beginning at five weeks and at 15 weeks. The score for Variable 7 (Avoidance) is taken at the fifth week, the "critical" period in the development of the pup. The scores for Variables 8, 9, and 10 are obtained by summing the performances obtained during the thirteenth and fifteenth weeks.

*11. Dominance.* This test is designed to measure the development of the dominance relationship ("peck order") within a litter under conditions of minimum competition. Except in the test situation the animals do not need to compete for food. In the test situation, each pup is paired off with every pup in his litter. After the pups are placed in the room, a bone is shown and dropped between them in such a way as to give each pup of the pair an equal chance to get the bone. The test is timed for 10 minutes and each reaction of each pup checked on the Dominance Test Record Sheet. The time during which each animal is in possession of the bone is recorded. Dominance is defined as the ability to keep possession of a bone through at least 8 minutes of a 10-minute period. Testing for dominance relationships is carried out at five, 11, and 15 weeks of age. Since the system appears to be fairly stable by 15 weeks, the score for this variable was taken at that time. Score values range from zero to one, from zero to complete dominance.[8]

*12. Caged dog.* This test, given at the 52nd week, is intended to show the animal's reactions to physical restraint while under stimulation. The litter is confined to cages which are two by four feet in floor size. The experimenter places food in front of the cages in sight of all dogs; then he feeds each dog, taking it out of the pen, and allowing it to walk up and down in full view of the other dogs for at least one minute. The observer records on the check list the reactions of the dog to be fed just before he is taken out of his cage and, in turn, the reactions of the other dogs while the fed dog is on the ground. This procedure is continued until ten such observations have been made on each dog. The arbitrary system of weights which have been attached to various behaviors which are elicited in this situation are as follows:

| | | | |
|---|---|---|---|
| Attentive | (0) | Growl | (1) |
| Indifferent | (0) | Howl | (1) |
| Vocalizations | | Lick chops | (1) |
| Bark | (1) | Pant | (1) |
| Whine | (1) | Yawn | (1) |

[8] The problem of getting a simple quantitative index of dominance relationships is extremely difficult. Professor Sewall Wright has developed one formulation which is too complex for our purposes. As a first approximation, the writer suggested the following empirical formulation: $D/n\text{-}1$, where $D$ equals the number of times animal X is dominant over animal Y and $n$ equals the number of animals in a litter. While this formulation does not correct for differences between litters, it does permit of an expression of dominance relationships within a litter which can be compared with dominance relationships of another litter.

| | | | |
|---|---|---|---|
| Muscular Tics | | Scratch pen | |
| Shake head | (1) | (both feet) | (5) |
| Wiggle ears | (1) | Shake self | (1) |
| Pawing pen | | Wag tail | (1) |
| (1 foot) | (1) | Urinate | (0) |
| General Activity | | Defecate | (0) |
| Stand | (3) | Shiver | (1) |
| Lie | (1) | Stereotyped Movements | |
| Sit | (2) | "Figure 8" | (8) |
| On hind feet | (4) | Pacing | (7) |
| Walk | (6) | Jump on pen side | (8) |

The scores from the sample of this study range from 10 to 120; the higher the score the greater the amount of activity in this particular experimental situation.

*13. Reactivity I, 14. Reactivity V.* The Reactivity Test is designed to measure the dog's emotional reactivity in situations involving isolation, social stimulation, and physical stimulation. In this test the subjects stand on a low platform restrained by adjustable loops about their legs. Several measures are recorded simultaneously, including heart-rate changes (see Variables 24-29) and body movements. Overt behavior is recorded by the observers, using a five-point scale in which hypoactivity is expressed by 1, and an extreme hyperactivity by 5. The test is divided into several episodes designated by letter symbols as follows: During the preparation period (Pr.) the responses of the animal to the adjustment of the apparatus are recorded. During the control (C1) period the animal is alone in a quiet, lighted room for 60 seconds. In the quieting period (Q) the experimenter enters, speaks softly to the dog, and places his hand near the dog's nose. The room is then darkened (Lo.) and the animal is alone for 60 seconds. In the bell period (B) a loud bell is sounded for 30 seconds while the animal is alone in a darkened room. The recovery period (Rb) immediately follows the cessation of the bell. After the lights have been turned on and the animals observed (Period C2), the observer enters, speaks in a loud voice, and places a muzzle rather roughly on the animal (Th.). The animals are again observed for one minute alone in a lighted room. Four single shocks are then administered from the secondary of a coil supplied by three volts on the primary. In the final period (Re.) the responses of the animal during release are recorded. The scores represent average reactivities (overt behavior) in 10 different situations. The score for Reactivity I is taken at the 18th week, the first time the Reactivity Test is given; the score for Reactivity V is taken at the 50th week, the last time the Reactivity Test is given.

*15. Heart-rate period.* A section of electrocardiogram is taken with the animal in a calm state as judged by external appearances. The average period in seconds of 30 heart beats is used for this measure. This score is taken at the 35th week; the higher the score, the lower the heart rate.

*16. Sinus arrythmia.* An arrythmia index is calculated from the electrocardiogram. This is defined as one hundred times the standard deviation of the heart period in seconds divided by the mean heart period. A sample of 30 beats made during slow respiration is selected for this measurement. High values indicate a strong vagus effect upon the heart. This score represents one reading taken during the period from 35 to 40 weeks of age.

*17. Systolic blood pressure.* Systolic blood pressures have been taken from the right hind leg using the special cup developed by Ferris and Hynes (26, p. 597). The average of 12 measures taken on three days, during which the animal appeared to be well adapted to the procedure, has been taken in all cases. This measure was taken during the period from 35 to 45 weeks of age.

*18. Temperature.* Rectal temperature is taken with a clinical thermometer. Two minutes are allowed for the thermometer to come to temperature. The dogs are placed in a holding cage at indoor temperature for one-half hour before readings are taken. This score is the average of five or six readings taken during the period from 35 to 45 weeks of age.

*19. Skin resistance.* Skin resistance of the dogs was measured by clipping an area about one and one-half inches square on the flank and applying battery clip electrodes on a flat surface of one square centimeter. Nonpolarizing electrode paste was used to insure good contact. Resistance readings to the nearest 100 ohms were made after the electrodes had been in place about five minutes, using a Garceau clinical dermohmeter. Successive readings were taken at two-minute intervals until an essentially stable level was obtained. This measure is the average of three scores taken on one day during the period from 35 to 50 weeks.

*20. Average heart rate.* The heart rate is taken at birth and on the birthday once per week thereafter up to and including sixteen weeks. A stethoscope is used, and the beats counted for a period of 15 seconds while the animal is held in the hands. The average heart rate is based on the rates from the fourth through the 16th weeks.

*21. Weight.* At the same time as the heart rate is taken, and immediately afterward, the animals are placed on the scales and weighed to the nearest ounce. The score is the total weight for Weeks 11 through 16, representing Period 4 in the social development of the pup.

*22. Heart-Rate Change III, 23. Heart-Rate Change IV.* On occasions of weighing, the ani-

mals are kept on the scales for one minute and the heart rate taken (as in Variable 20) immediately after this one-minute period. The heart-rate change is obtained by subtracting the first reading from the second. That for Period III (socialization) is the average change observed in Weeks 5 to 10. That for Period IV (juvenile) is the average change observed in Weeks 11 through 16.

*Heart-Rate Changes: 24. Control-quieting, 25. Lights-out-bell, 26. Bell-recovery, 27. Control-threatening, 28. Threatening-control, 29. Control-shock.* All of these scores are the average of five arithmetic differences between the heart rate under one situation and that in the following situation: the descriptive terms indicate the situational changes in each case. The heart rate in any given time is determined by many factors, two of the most important of which are the action of the vagus and that of the accelerator nerves. The changes in rate which we observe are rapid and can be assigned primarily to differences in the activity of these two nerves. These readings are taken during the Reactivity Tests (see Variables 13 and 14 for complete details).

*30. Reactivity (control), 31. Reactivity (bell), 32. Reactivity (shock).* These measures are variants of Reactivity I and Reactivity V (see Variables 13 and 14). Each of these measures is the average reactivity rating (hypo- to hyperactivity on a one to five rating scale) in one particular type of situation for the five tests given at eight-week intervals from 18 to 50 weeks. During the bell period the animal is alone in a darkened room while a loud bell is sounded close by. During the shock period four single shocks from a model airplane spark coil are applied to the left foreleg at five-second intervals. Whereas Reactivity I and Reactivity V measure average reactivities in 10 different situations, these three tests measure the reactivity of the animal alone (Variable 30), under auditory stimulation (Variable 31), and when under moderate pain (Variable 32).

### *The Problem of Experimental Dependence*

While the concept of experimental dependence is well defined, there has been little experimental work done on the problems the concept presents, and certainly the implications of experimental dependence for animal studies is not clear. Experimental dependence may be defined as the appearance of an incidental common factor due to the sharing of the uniqueness of two or more test scores derived from the same performance (91, pp. 440-441). When this situation occurs, it is recommended that only one of the several tests be used so as to avoid the introduction of an incidental common factor. In comparative and physiological studies the investigator is very often interested in recording both physiological and psychological measures. Often it is advisable to record several such measures simultaneously—that is, to record multiple reactions to a single situation. Such situations occurred several times in this study. Let us consider Variables 29 (Heart-Rate Change [control-shock]) and 32 (Reactivity [shock]) as an example. The investigator recorded several measures in response to a shock stimulus—two of these measures appear in this test battery as heart rate change and reactivity. A literal interpretation of the implications of experimental dependence would demand that only one of these variables be used. From the point of view of the physiological psychologist, however, such omission would be contrary to the intent of the investigation. Since there is no evidence to indicate that the traditional interpretation of experimental dependence is relevant here, several such measures were included in the current test battery. These measures included heart-rate changes and reactivities in three different situations. The paired measures are as follows: Variables 24 and 30, 25 and 31, and Variables 29 and 32.

In a previous section it was mentioned that the test battery includes repeated measures. It would appear that such a procedure would introduce more experimental dependence. Why did we repeat several measures despite our awareness of experimental dependence? Briefly, this procedure was followed because there

was reason to believe that, due to developmental changes occurring in our subjects (80), the same measure might be measuring different things at different points in time.[10] Since it was impossible to telescope the administration of all the tests within one phase of the animal's development, it was thought advisable to repeat the administration of certain tests several times. While this is an interesting and important problem, it was not the primary concern of this particular study. It was, therefore, decided to compromise by introducing repeat measures for only a few variables as a secondary interest in this first, exploratory, factorial investigation of dog behavior. Furthermore, it was decided to include repeat measures which would involve different developmental phases in the dog's growth.[11] In most cases, therefore, repeat measures were used covering Scott's (80) Developmental Periods 3 and 4, the socialization and juvenile periods. Standard measures which were repeated in this manner include Timidity-Confidence, Inhibition-Activity, and Heart-Rate Change. In addition, one heart-rate measure was included covering the animal's "youth" (Variable 20), and one heart-rate measure was taken in the "mature" (Variable 15) animal.[12] The same reasoning was used for including Variable 13 (Reactivity I) and Variable 14 (Reactivity V). An additional Timidity-Confidence measure (Variable 2) was included because it was given during the "critical" period in the dog's social development.

Perhaps we can sum up the problem of experimental dependence as follows.[13] Theoretically, if experimental dependence is operating completely, experimentally dependent variables should identify an incidental common factor. If experimental dependence is not operative, then we should not expect what appear to be experimentally dependent variables to identify an incidental common factor. If experimental dependence is partially operative, then we should expect experimentally dependent variables to identify

[10] It should be pointed out that this is not necessarily the same problem as test reliability. There are real problems connected with concepts of test reliability when applied to situations where legitimate developmental changes occur within the organism. The point is that the factorial composition of a given test variable is more dependent upon what is going on inside the organism than on what is written in the test procedures.

[11] The writer is indebted to Dr. J. P. Scott and Dr. J. L. Fuller for advice in deciding upon which repeat variables to include in the test battery.

[12] For the purpose of this study there was no rationale for setting up Variable 15 (Heart-Rate Period) as the inverse of Variable 20 (Average Heart Rate). These two measures came from different experimental situations, each appropriate for its own setting.

[13] There is one additional problem related to experimental dependence that will be mentioned, although it cannot be adequately treated in this report. This is the problem of the effect of a given test performance on a subsequent test performance (which is of particular interest in learning and problem-solving domains), and the more generalized problem of what test order to follow in administering a large battery of tests to animal populations. This problem becomes further complicated with variations in the time intervals between and during testing sessions (i.e., temporal dependence). Both of the above mentioned problems are involved in Variables 24-29 (i.e., heart-rate changes in a series of changing situations). While it is true that this problem of test order is theoretically soluble by introducing completely counterbalanced order, it should be obvious that such a solution is not a practical one. For example, if our test battery consisted of only four tests, and counterbalanced order were introduced, it would be necessary to administer the test battery in 24 different orders. If the test battery were increased to five, 80 different orders of test administration would be necessary. As the number of tests approaches the number in a typical factorial study, the number of test orders permitting completely counterbalanced order approaches astronomical figures.

a common factor, although not an extraneous factor (i.e., other experimentally independent variables would also have high loadings on the factor in question). The thought is that some of the apparently experimentally dependent variables will show experimental dependence in the factorial analysis and that others will not. The results which obtained will be discussed in Section III.

*The Factorial Analysis*

Since it has been shown that simple structure is brought out in clearest form by the procedure of normalizing raw scores before factoring (91, p. 369), all test-score distributions were normalized. The scores were arranged in a frequency distribution from high to low. For each score the cumulative percentage was computed, and five sigma values determined along the abscissa in accordance with the appropriate area under the normal curve. Single digit numbers (from zero to nine) were then assigned to each of the 10 half-sigma intervals. The 496 Pearson product-moment correlation coefficients were determined from the necessary sums and cross-products computed by means of punched cards and IBM tabulating machines.[14]

Ten factors were extracted from the correlation matrix by means of the centroid method of factoring (91). The communality estimates were made by entering the highest correlation in the column in the original and subsequent residual matrices (91). The frequency distribution of the residuals of each of the 10 factors was determined. The average deviation of residuals dropped from .13 for Factor 1 to .04 for Factors 8, 9, and 10. While there was a plateau at Factors 4 and 5, there was a decline for Factors 6, 7, and 8. The constant plateau for Factors 8, 9, and 10 strongly suggests that the extraction of additional factors is unnecessary. The 10th factor residuals ranged from minus .14 to plus .11 with a root mean square deviation of .0448.

The orthogonal factor matrix F, showing the factor loadings of the 32 variables, together with their communalities, is presented as Table 1. It is of interest to note that, with the exception of Variable 11 (Dominance), all the communality values are .40 or above.

An oblique simple structure, shown as Table 2, was obtained for the 10 factors after 20 rotations. The projections of the test vectors on the rotated reference axes were computed by means of a matrix multiplier (91, 94). Rotations 1 through 14 were accomplished through the use of two-dimensional radial rotations (91); rotations 15 through 20 involved the single-plane (91) and least-square[15] rotational procedures.[16] Inspection of Table 2 reveals the following

[14] In order to conserve space and the cost of reproducing large tables, the writer has deposited a copy of the correlation matrix with the American Documentation Institute. For those who are interested, a copy of this table may be obtained by ordering Document No. 4669 from the ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington 25, D.C., remitting in advance $1.25 for 35 mm. microfilm, or $1.25 for photoprints. Make checks payable to Chief, Photoduplication Service, Library of Congress. A complete copy of the original thesis, containing all of the factor matrices, as well as other tables, can be made available through the library of the University of Chicago or through direct contact with the author.

[15] The least-square method of rotating is a procedure which has been devised by Professor L. L. Thurstone. The method is in use at the Psychometric Laboratory, and has not been published.

[16] The writer is indebted to Professor Thurstone, Mr. James Degan, and Miss Helen Heath, all of the Psychometric Laboratory, for carrying out the necessary procedures in rotating to simple structure.

TABLE 1

UNROTATED ORTHOGONAL FACTOR MATRIX F*

| Test No. | I | II | III | IV | V | VI | VII | VIII | IX | X | $h_i^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | −10 | 55 | −10 | −12 | −30 | −13 | −21 | −17 | 18 | 22 | .60 |
| 2 | 46 | −04 | 29 | 07 | 12 | −26 | 19 | 17 | 10 | −03 | .46 |
| 3 | 47 | 19 | 20 | 41 | −21 | 11 | −07 | −12 | 06 | 28 | .62 |
| 4 | 53 | −14 | 27 | 52 | 05 | 07 | −18 | −22 | 11 | −08 | .75 |
| 5 | 13 | −27 | 34 | −06 | 26 | 09 | −12 | −24 | 16 | 24 | .44 |
| 6 | 45 | −28 | 17 | −36 | 28 | −06 | −06 | 12 | 24 | 10 | .61 |
| 7 | 47 | 32 | −50 | −10 | 28 | −23 | 05 | −23 | −14 | 09 | .79 |
| 8 | −59 | −17 | 45 | 30 | −14 | 14 | −14 | 17 | 21 | −05 | .80 |
| 9 | −48 | 18 | 42 | 17 | 16 | 18 | 30 | 06 | 15 | 12 | .66 |
| 10 | −40 | −06 | 33 | −07 | 11 | 38 | 12 | 18 | −16 | 22 | .55 |
| 11 | 05 | 17 | 11 | −12 | 19 | 13 | 15 | −15 | −19 | 02 | .19 |
| 12 | −10 | −17 | 18 | 26 | −17 | −39 | −20 | −32 | −07 | 14 | .49 |
| 13 | 49 | 17 | 42 | −09 | −05 | 22 | 15 | −17 | 29 | −22 | .69 |
| 14 | 47 | 51 | 26 | 21 | 15 | −16 | −30 | 14 | −15 | −05 | .78 |
| 15 | −57 | 28 | −05 | 22 | 19 | 12 | 24 | 12 | 18 | 04 | .61 |
| 16 | −36 | 48 | −12 | 06 | 17 | −08 | 15 | −31 | 37 | 19 | .70 |
| 17 | 13 | 51 | 16 | −29 | −16 | −15 | 16 | −30 | 10 | 06 | .56 |
| 18 | −20 | 45 | 48 | 15 | −19 | 12 | 19 | 05 | −18 | 20 | .66 |
| 19 | 16 | 47 | −33 | 22 | −23 | −09 | 06 | 10 | −11 | 25 | .55 |
| 20 | 71 | −34 | 13 | −34 | 37 | 06 | −13 | −06 | 07 | 11 | .93 |
| 21 | −29 | 23 | 14 | −34 | 21 | −10 | 41 | 18 | 11 | 18 | .57 |
| 22 | 68 | −12 | −05 | 04 | 17 | 05 | −21 | 12 | −18 | 13 | .62 |
| 23 | 35 | 23 | −26 | 16 | 25 | −17 | 18 | 27 | 17 | −09 | .50 |
| 24 | 52 | −28 | −06 | 20 | 07 | 20 | 17 | 39 | 09 | 05 | .63 |
| 25 | 21 | −26 | 20 | −08 | −38 | −28 | 38 | 20 | −03 | −10 | .58 |
| 26 | −26 | 32 | −32 | 20 | 35 | 09 | −34 | −09 | 05 | −20 | .61 |
| 27 | 32 | −28 | −44 | 18 | −21 | 23 | 17 | 15 | 14 | −11 | .59 |
| 28 | −53 | 16 | 43 | −19 | 10 | −26 | −39 | 19 | 03 | −08 | .80 |
| 29 | 08 | 22 | −11 | −36 | −20 | 09 | −10 | 32 | 14 | 18 | .41 |
| 30 | 60 | 56 | 33 | 25 | 06 | 18 | −15 | −04 | −14 | −18 | .96 |
| 31 | 56 | 48 | 38 | 32 | 02 | −16 | 05 | 05 | 08 | −06 | .83 |
| 32 | 47 | 37 | 27 | −04 | −23 | 34 | −32 | 09 | 11 | −14 | .74 |

* The decimal point has been omitted for all factor loadings.

facts. For every factor more than half of the entries were within the range ±.10, the number of such entries varying from 17 for Factor H to 23 for Factor F for the 32 variables. Thirty-one negative projections greater than .10 are in the table. Eight of these negative projections ranged from .30 to .54, the remainder were in the range from .10 to .30. Six of the 10 factors had one significant (.30 or greater) negative loading, one (Factor B) had two significant negative projections, and three had no significant negative values. Five of the eight significant negative loadings involved heart-rate changes, the negative value reflecting a deceleration of heart rate for the specified experimental situation.

The transformation matrix, A, is shown as Table 3. The columns of this matrix are the direction cosines of the reference vectors with respect to the original orthogonal matrix, F. Postmultiplication of the orthogonal matrix by the transformation matrix gives us the rotated factorial matrix, V.[17] The cosines of the angles between the reference axes are shown in Table 4.

Every test has at least one loading of .30 or greater. The number of entries between .20 and .30 (absolute values) for the 10 factors is 33, with a range of two for Factors A, B, E, and G, to seven for

[17] See Footnote 14.

TABLE 2

ROTATED OBLIQUE FACTOR MATRIX V*

| Test No. | A | B | C | D | E | F | G | H | J | K |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 43 | 16 | 03 | −05 | −07 | 22 | 01 | −03 | −21 | 30 |
| 2 | 00 | 15 | 19 | 16 | 30 | −02 | 34 | 35 | −08 | 00 |
| 3 | −01 | 00 | 18 | 42 | −02 | 05 | 03 | 19 | 01 | 40 |
| 4 | −03 | −02 | −01 | 55 | 01 | 01 | −05 | 21 | −01 | 01 |
| 5 | 00 | 05 | 37 | 27 | 04 | −09 | −07 | −20 | 03 | 06 |
| 6 | 00 | 03 | 47 | −04 | 17 | 06 | 09 | −02 | −23 | 01 |
| 7 | 22 | −05 | −01 | −28 | 02 | −06 | −09 | 46 | −02 | 02 |
| 8 | −19 | 18 | −01 | 43 | 11 | −05 | −08 | −30 | −03 | 03 |
| 9 | −04 | 02 | 07 | 18 | 38 | 00 | 12 | −11 | 21 | −03 |
| 10 | −36 | 00 | 20 | −06 | 00 | −05 | −08 | −27 | 38 | 07 |
| 11 | 04 | −06 | −04 | −19 | −03 | 09 | 06 | 03 | 34 | −14 |
| 12 | 10 | 38 | −02 | 49 | −20 | −36 | 04 | −03 | 00 | 19 |
| 13 | 35 | −26 | −01 | −02 | 15 | 58 | 38 | −04 | 00 | −24 |
| 14 | −03 | 39 | −01 | 03 | 03 | 16 | −02 | 64 | 09 | 08 |
| 15 | −02 | −05 | −07 | 02 | 42 | −05 | −09 | 03 | 01 | −04 |
| 16 | 41 | 00 | −02 | 05 | 32 | 00 | −02 | 01 | −07 | 04 |
| 17 | 56 | 03 | −02 | −25 | 02 | 35 | 43 | −01 | 04 | 01 |
| 18 | −04 | 17 | 00 | 00 | 01 | 10 | 27 | 04 | 40 | 18 |
| 19 | 00 | 03 | 00 | −05 | 01 | −04 | −01 | 38 | −05 | 39 |
| 20 | −04 | −06 | 44 | 00 | −01 | 06 | −04 | 02 | −06 | −02 |
| 21 | 10 | 07 | 24 | −26 | 40 | 01 | 27 | −01 | 05 | −01 |
| 22 | −28 | 03 | 26 | 03 | −13 | −06 | −17 | 33 | 02 | 18 |
| 23 | 00 | −04 | 03 | −02 | 45 | 01 | 01 | 56 | −25 | −02 |
| 24 | 08 | −43 | 05 | 26 | −01 | −01 | 01 | −04 | 03 | −03 |
| 25 | 01 | 00 | 01 | −02 | 02 | −03 | 61 | 00 | −05 | 01 |
| 26 | 05 | 06 | −31 | −04 | 08 | 03 | −54 | 17 | −05 | −21 |
| 27 | −14 | −52 | −04 | 06 | 04 | 05 | −04 | 00 | −26 | 02 |
| 28 | 02 | 64 | 01 | −02 | 02 | 01 | −06 | −06 | −02 | −07 |
| 29 | 02 | 00 | 28 | −31 | 01 | 26 | 01 | −06 | −24 | 27 |
| 30 | 05 | 06 | −17 | −04 | −03 | 44 | 03 | 47 | 26 | −09 |
| 31 | 15 | 20 | 00 | 18 | 26 | 24 | 30 | 57 | 02 | 06 |
| 32 | 08 | −06 | 00 | −01 | −14 | 61 | 00 | 03 | −05 | 02 |
| Sum | 1.49 | 1.10 | 2.09 | 1.47 | 2.63 | 2.52 | 1.65 | 3.31 | .21 | 1.43 |

* The decimal point has been omitted for all factor loadings.

Factor J. The other factors had either three, four, or five entries in the range from .20 to .30. These loadings below .30 can be regarded as being of little value in the interpretation of the factors.

## III. Interpretation and Discussion

### *The Factors*

While it is probably true that each of the peripheral effects (physiological,

TABLE 3

MATRIX A OF THE TRANSFORMATION FA = V

| Factor | A | B | C | D | E | F | G | H | J | K |
|---|---|---|---|---|---|---|---|---|---|---|
| I | 03 | −16 | 10 | 01 | −03 | 21 | 16 | 37 | −09 | 07 |
| II | 35 | 14 | −19 | −33 | 17 | 43 | 07 | 41 | 10 | 05 |
| III | −01 | 37 | 16 | 26 | 04 | 16 | 41 | −12 | 32 | −04 |
| IV | −31 | 04 | −21 | 73 | 21 | −37 | −24 | 43 | 02 | 15 |
| V | −18 | 12 | 17 | −05 | 44 | −24 | −38 | 36 | 15 | −36 |
| VI | −27 | −68 | 00 | −14 | −16 | 46 | −35 | −42 | 29 | −10 |
| VII | 10 | −46 | −06 | −20 | 42 | −05 | 66 | 04 | 23 | −13 |
| VIII | −61 | 22 | 29 | −13 | 32 | −04 | −05 | 36 | −23 | 16 |
| IX | 48 | −22 | 30 | 34 | 65 | 31 | 09 | −22 | −82 | −03 |
| X | −23 | 20 | 81 | 32 | 02 | −49 | −17 | −09 | 00 | 89 |

TABLE 4

COSINES OF ANGLES BETWEEN REFERENCE VECTORS $\Lambda_{pq}$

| Factor | A | B | C | D | E | F | G | H | J | K |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 99 | | | | | | | | | |
| B | −14 | 1.01 | | | | | | | | |
| C | −25 | 20 | 1.00 | | | | | | | |
| D | −15 | 22 | 28 | 1.01 | | | | | | |
| E | 11 | −05 | 28 | 21 | 1.00 | | | | | |
| F | 47 | −42 | −29 | −46 | −03 | 1.00 | | | | |
| G | 44 | −05 | −10 | −17 | 18 | 23 | 1.00 | | | |
| H | −23 | 39 | −09 | 03 | 36 | −24 | −05 | 1.00 | | |
| J | −31 | −01 | −29 | −28 | −45 | −09 | 05 | 02 | 1.01 | |
| K | −26 | 29 | 67 | 40 | −11 | −42 | −11 | 01 | −14 | 1.01 |

social, psychological) observed in the 32 variables of this study is due to many specific determinants, the logic of the factorial analysis design implies that a relatively small number of "functional unities" or factors may underlie these individual expressions. It must be explicitly stated that knowledge of a particular factor does not constitute knowledge of an underlying mechanism or process. However, there is the hope that knowledge of a given factor will help focalize crucial experiments which could lead to a detailed understanding of the underlying processes. Thus, we make no pretense of describing mechanisms of emotionality in this study.

In conceptualizing a factor we must be guided entirely by the dictates of the obtained "simple structure" (or by whatever other criterion proves to be fruitful) regardless of possible preconceptions. We must also be guided by general knowledge and concepts which make up the history of the domain in question. In the history of the emotionality domain, "homeostasis" has been a unifying and fruitful concept (36, 52). While it must be admitted that formulations other than those offered here can be given, the interpretations which follow are given in conformity with homeostatic principles. That is, it is proposed that the psychophysiological factors of this study involve underlying homeostatic mechanisms which are operative in the organism's interactions with the external environment.[18]

The importance of simple structure in locating the reference frame has been pointed out by Thurstone (91), and the implications of this concept for factorial studies of animal behavior have been reviewed by Royce (72). The "simple structure" factors found in this study will now be considered as to their possible interpretation in terms of psychophysiologically useful concepts.[19]

### *Interpretation of Factor A*

Five tests have loadings of .30 or higher on this factor. The relevant variables are:

| | |
|---|---|
| 17. Systolic Blood Pressure | +.56 |
| 1. Vocalizations | +.43 |
| 16. Sinus Arrythmia | +.41 |
| 13. Reactivity I | +.35 |
| 10. Attraction | −.36 |

This factor is interpreted as *Timidity*

[18] This implies that behavior is determined by mechanisms that are concerned with maintaining homeostasis.

[19] The semantic problem involved in naming a factor is a difficult one. It is particularly difficult in this study for the simple reason that each factor is identified by both psychological and physiological variables. Ideally, we need a new terminology, a psychophysiological terminology which adequately covers both the psychological and physiological manifestations of the underlying mechanisms.

*I*. It is regarded as a psychophysiological factor characterized psychologically by freezing (Variable 10) and internally by liberation of aroused energy via physiological mechanisms (e.g., blood pressure, arrythmia). Note that the factor is identified by two psychological (Variables 10 and 13) and three physiological (Variables 1, 16, and 17) variables, and that the larger portion of the variance is attributable to the physiological tests. This point cannot be stressed too much since it points up the fact that the differentiation between this factor and Factor H probably lies in the mode of emotional expression—in this case via internal mechanisms. The physiological variables are particularly provocative in the light of such standard references as Cannon (12), Bard (6), Woodworth (106), and Landis (58), who stress the importance of cardiovascular involvement in emotionality. The tie-up of blood pressure and sinus arrythmia to freezing behavior is particularly provocative when viewed in the light of the report of Anderson, Parmenter, and Liddell, who say that "sheep in which an experimental neurosis has been developed reveal, upon examination, a cardiac disorder which is characterized by a rapid and irregular pulse . . ." (4). Such irregularity of pulse is reflected in Factor A in Variable 16, Sinus Arrythmia. Furthermore, the high loading of systolic blood pressure is understandable when viewed as varying with increased heart rate and irregular beating.

The presence of vocalizations (Variable 1) on this factor adds to the interpretation of Factor A as a timidity factor. Darwin (19), Landis (58), Young (108) and others agree that animal vocalization is probably one type of emotional expression. The fact that it shows up on this particular factor is in essential agreement with common-sense notions of vocalizing under stress as one expression of timidity. It should also be pointed out that this particular variable has no significant variance on any other interpretable factor.

On the behavioral side, the reports of Thorne (89) and W. T. James (49) are relevant, particularly Thorne's study on approach and withdrawal behavior. Thorne suggests two types of timidity expression, one of which can be called "fearful." James pursues Pavlov's notion of an excitable and inhibitable type of dog, the implication for the present study being that the ability to inhibit is related to Timidity I. Further, Billingslea (9), in his factorial study of the rat, emerges with three factors, two of which are called "freezing" and "timidity." It seems reasonable that his "freezing" factor is similar to Thorne's "fearful" concept and to Timidity I. While none of these studies referred to contain physiological measures, the psychological picture of freezing and inhibitability is consistently proposed. It is suggested that the physiological variables with high loadings on Factor A provide the energy outlet for the "freezing," "fearful," or "inhibitable" mechanisms cited by Billingslea, Thorne, and James.

Because of the relevance of references cited above, and the importance of avoidant behavior in identifying timidity factors, further differentiation between Factors A and H will be brought out in the discussion of Factor H.

### *Interpretation of Factor B*

Five tests have loadings of .30 or higher on this factor. The relevant variables are:

| | |
|---|---|
| 28. Heart-Rate Change (threatening-control) | +.61 |

| | |
|---|---|
| 14. Reactivity V | +.39 |
| 12. Caged Dog | +.38 |
| 24. Heart-Rate Change (control-quieting) | −.43 |
| 27. Heart-Rate Change (control-threatening) | −.52 |

This factor is interpreted as *Heart Reactivity to Social Stimulation.* It is regarded as a psychophysiological factor dominated by heart-rate changes in social situations. Note that none of the other heart-rate measures has a significant loading on this factor, but that all the heart-rate measures involving social situation (i.e., quieting or threat from the experimenter—Variables 24, 27, and 28) have quite high loadings. Variable 28 reflects an accelerated heart rate, whereas Variables 24 and 27 represent decreases in rate. Why the changes take these particular directions in each instance is not clear. All that can be said, therefore, is that the heart rate is modified under social stimulation, sometimes increasing, at other times decreasing.

The behavioral picture is one of hyperactivity (Variables 12 and 14), with one of the two variables, the Caged Dog test, reflecting a high activity level in a restraint-under-social-stimulation situation. Thus, the total picture is one of hyperresponse to social stimulation, with particular emphasis on cardiac reactivity.

*Interpretation of Factor C*

Four tests have loadings of .30 or higher on this factor. The relevant variables are:

| | |
|---|---|
| 5. Inhibition-Activity IV[20] | +.47 |
| 20. Average Heart Rate | +.44 |
| 5. Inhibition-Activity III[20] | +.37 |
| 26. Heart-Rate Change (bell-recovery) | −.31 |

This factor is regarded as uninterpretable because of underdetermination. That is, by virtue of the inadequacy of the number and kinds of variables which have identified this factor, it is not possible to determine its nature. Only four variables have significant loading on this factor, and two of the four variables are experimentally dependent.

*Interpretation of Factor D*

Five tests have loadings of .30 or higher on this factor. The relevant variables are:

| | |
|---|---|
| 4. Timidity-Confidence IV[20] | +.55 |
| 12. Caged Dog | +.49 |
| 8. Aggressiveness | +.43 |
| 3. Timidity-Confidence III[20] | +.42 |
| 29. Heart-Rate Change (control-shock) | −.31 |

This factor is interpreted as *Aggressiveness.* It is primarily a psychological factor characterized behaviorally by agitated hyperactivity in response to social and inhibitory stimulation (Variables 8 and 12), and by an overt appearance of confidence (Variables 3 and 4).

Perhaps the most provocative psychological variable with a high loading on this factor is Variable 12 (Caged Dog). This experimental situation represents a fairly direct test of how much the animal inhibits himself in response to a provoking series of social stimulations. High scores on the Caged Dog test reflect much vocalizing, much generalized body movement, and possible urination and defecation. In extreme cases there would be very stereotyped hyperactivity such as very rapid pacing, "figure eight" pacing, and perhaps actual jumping and biting directed at the confining cage.

Variable 8 (Aggressiveness) is a measure which involves social interaction between the puppy and the experimenter. Animals with high scores in this human "handling" situation would exhibit such behavior as "leaping to touch hand,"

[20] These variables are experimentally (temporally) dependent; see Table 5.

"dashing about," "barking," "snarling," and "growling."

Variables 3 and 4 (Timidity-Confidence) are measures of motor expression in the tradition of Darwin (19), and more recently of Allport and Vernon (1), and others. The tests simply involve very mild inhibitory stimulation while the animal is on the weighing scales. The indication of "boldness" or "confidence" which is reflected by these vectors seems consistent with this essentially "outward going" factor.

The relevance of Variable 29 is not clear. This variable reflects a deceleration of heart rate following electric shock. While such a phenomenon is not in any way contradictory to the interpretation of Factor D, it also does not contribute to a clearer understanding of the factor.

*Interpretation of Factor E*

Six tests have loadings of .30 or higher on this factor. The relevant variables are:

| | |
|---|---|
| 23. Heart-Rate Change IV | +.45 |
| 15. Heart-Rate Period | +.42 |
| 21. Weight | +.40 |
| 9. Et-epimeletic | +.38 |
| 16. Sinus Arrythmia | +.32 |
| 2. Timidity-Confidence I | +.30 |

This factor is regarded as uninterpretable. While there appear to be enough tests with significant loadings on this factor, a careful consideration of the variables does not lead to an adequate hypothesis as to its nature. There are, however, several remarks concerning this partially identified factor which can be offered.

Factor E is primarily a physiological factor characterized behaviorally by food seeking (Variable 9) and physiologically by irregular heart activity (Variables 23, 15, and 16). High scores on Heart-Rate Period (Variable 15) reflect a slow heart rate and the possibility of inhibitory activity via the vagus nerve. Variable 23 (Heart-Rate Change IV), on the other hand, reflects an increased heart rate in a minimally stimulating situation (weighing on the scales). These two facts, combined with high loading of Sinus Arrythmia (Variable 16), present a consistent picture of irregularity of heart rate. The significant loading of Weight (Variable 21), another physiological variable, can be taken as a gross measure of general health and metabolic processes. As such, a high score on this test could be indicative of heaviness and could reflect an essentially anabolic metabolism.

Comparisons with previous factorial studies are suggestive since this factor appears to be similar to the "energy discharge control" factor of Freeman (32), the "central" factor of Jost (52), the muscular tension factor of Wenger (97, 99), and Duffy (22), and the "parasympathetic" factor of Darling (6). A possible point in common among the variables of Factor E of this study, as well as the conceptualizations of cited literature, could be related to some anabolic aspect of Cannon's homeostatic theorizing. Many more autonomic indices will have to be included in the test battery in order to properly identify this factor. After further exploration in future factorial studies, Factor E may emerge as some kind of an "energy conserving" factor.

*Interpretation of Factor F*

Five tests have loadings of .30 or higher on this factor. The relevant variables are:

| | |
|---|---|
| 32. Reactivity (shock) | +.61 |
| 13. Reactivity I | +.58 |
| 30. Reactivity (control) | +.44 |
| 17. Blood Pressure | +.35 |
| 12. Caged Dog | −.36 |

This factor is interpreted as *Activity Level*. It is primarily a psychological factor characterized by activity indices in a wide variety of situations.

It should not be surprising to find an "activity-level" factor in this domain, since activity measures and concepts so dominate our thinking on problems of phasic and chronic emotionality and of emotionality disorders. Among others, both Freeman and Guilford make much of an "activity" continuum in the study of personality structure. Of the five reactivity measures in this test battery, Reactivity V and Reactivity (bell) did not have significant loadings on this factor. In addition, neither of the In-

hibition-Activity indices have significant loadings. The latter have significant loadings on Factor C, however, and are test situations which are much more unstructured than the situational nature of the reactivity tests. The reasons for the obtained separation of the several reactivity indices is not clear.

The presence of Systolic Blood Pressure (Variable 17) on this factor suggests that an aspect of "tension" may be part of the underlying psychophysiological mechanism of this factor. This idea would appear to be in agreement with Guilford's (40) "general drive" and "nervousness" factors. More direct measures of muscle tension would be needed to test for the extent to which this notion is true.

The predominating variance of this factor is reflected in the three reactivity measures of Variables 13, 30, and 32. It will be recalled that these variables are ratings of hypo-hyperactivity in such situations as activity in response to bell stimulation, shock, lights out, threatening, displacing stimulation. The fact that not *all* of the activity measures have significant loadings on this factor is not disturbing. In fact, had all reactivity measures entered into this parameter, it would provide reasonable assurance for the complete operation of experimental dependence.[21] Furthermore, it will be noted that Variable 31, Reactivity (bell), has a large portion of its variance distributed over Factors G and H. Since these are factors of "audiogenic reactivity" and a hyperactive kind of timidity (Timidity II), it seems somewhat reasonable that Reactivity (bell) does not contribute to a strictly "activity-level" factor, although obviously hyperactivity is involved in both Factors G and H. Reactivity V (Variable 14) seems to have spread itself over Factors B and H, where it adds to the hyperactive components of Heart Reactivity and Timidity II. Why it is that Reactivity measures 13, 30, and 32 should have formed one block, with Variables 14 and 31 breaking off independently is not at all clear, unless it be that the block of 13, 30, and 32 is simply the remainder of what was pulled away in the manner indicated above.

The negative loading of Variable 12, while not necessarily contradictory, is confusing, and cannot be adequately accounted for at this time.

*Interpretation of Factor G*

Six tests have loadings of .30 or higher on this factor. The relevant variables are:

| | |
|---|---|
| 25. Heart-Rate Change (lights-out bell) | +.61 |
| 17. Blood Pressure | +.43 |
| 13. Reactivity I | +.38 |
| 2. Timidity-Confidence I | +.34 |
| 31. Reactivity (bell) | +.30 |
| 26. Heart-Rate Change (bell-recovery) | −.54 |

This factor is interpreted as *Audiogenic Reactivity.* It is a psychophysiological factor characterized psychologically and physiologically by very acute reactivity to auditory stimulation. It should be noted that every variable, both psychological and physiological, which has bell stimulation in the experimental set-up has a significant loading on this

[21] It must be pointed out that experimental dependence is responsible for a small portion of the common factor variance of this factor because of the inclusion of three longitudinal (Variables 30, 31, and 32) and two cross-sectional (Variables 13 and 14) indices of reactivity. That is, a small portion of the total score for any one of the reactivity measures included is also a small portion of each of the other reactivity measures because of the mechanics involved in obtaining each individual score. For a more complete understanding of this, refer to the detailed descriptions of Variables 13, 14, 30, 31, and 32 on earlier pages.

factor. The cardiovascular variables of Heart-Rate Change (Variables 25 and 26) and Blood Pressure (Variable 17) have the highest projections on this factor, and point up the essentially physiological nature of the factor. In particular, they point to cardiovascular mechanisms as possibly of great importance in the sequence of physiological events in response to strong auditory stimulation. The presence of Temperature (Variable 18, with a loading of +.27) on this factor is also provocative since it is generally known that high temperatures accompany the widespread nervous activity of convulsions and seizures. The fact that several indices of hyperactivity (e.g., Reactivity I, Reactivity [bell]) have significant projections on this factor is also important, since it is generally recognized that in extreme responsiveness to auditory stimulation, such as occurs in audiogenic seizures, a characteristic hyperactivity accompanies the response.

The identification of Audiogenic Reactivity as a factor of emotionality provides an interesting example of the exploratory nature of the factorial approach in psychobiological domains. This is true in terms of the previously expressed idea that identification of a factor may lead to further experiments which could lead to a detailed description of underlying mechanisms.[22] The probabilities are high that the factor of Audiogenic Reactivity is related in some way to audiogenic seizures and other research on auditory stress. It is interesting at this point to note the recent study of Yeakel *et al.* on the rise in blood pressure of rats subjected to auditory stimulation. They report:

"... after a year's exposure to the sound of a blast of compressed air, five minutes a day for five days a week, the average systolic pressure of twenty-five grey Norway rats rose from an initial value of 113 m.m. to 145 m.m. . . . Monthly averages indicate that the rise in systolic blood pressure of the experimental rats tended to occur in the ninth month after air blasting began" (107, p. 126).

Thus, there is evidence for a sound-induced elevation of blood pressure. In a subsequent study, McCann *et al.* (65, p. 131) provide evidence that this audiogenic blood-pressure rise is mediated by the adrenal cortex. It is not inconceivable that organisms with high blood pressure from constitutional factors would succumb very rapidly to intense auditory stimulation. If a tie-up can be established between the work of Witt and Hall (105), Fuller (35), Ginsburg, Miller and Zamis (39), and Hall (42) on the inheritance of susceptibility to audiogenic seizures and the blood pressure accompaniments of auditory stimulation reported in this and the Yeakel study cited above, it may lead to a detailed explanation of cardiovascular mechanisms which may be involved in audiogenic seizures.

### *Interpretation of Factor H*

Nine tests have loadings of .30 or higher on this factor. The relevant variables are:

| | |
|---|---|
| 14. Reactivity V | +.64 |
| 31. Reactivity (bell) | +.57 |
| 23. Heart-Rate Change IV[23] | +.56 |
| 30. Reactivity (control) | +.47 |
| 7. Avoidance | +.46 |
| 19. Skin Resistance | +.38 |
| 2. Timidity-Confidence I | +.35 |
| 22. Heart-Rate Change III[23] | +.33 |
| 8. Aggressiveness | −.30 |

This factor is interpreted as *Timidity II*. It is regarded as essentially a psychological factor of timidity characterized by withdrawal (Variables 7 and 8) and by hyperactivity (Variables 2, 14, 22, 23, 30, and 31).

Note that this factor, while related to Factor A in that both factors have the withdrawal component, is heavily freighted with behavioral variables (2, 7, 8, 14, 30, 31). Perhaps the distinction between these two factors lies in the fact that in Timidity I aroused energy is internally liberated (i.e., via physiological mechanisms), whereas in Factor H aroused energy is externally liberated

[22] It is obvious, however, that in this case research on auditory hyper-responsiveness has both preceded and paralleled the identification of the factor of audiogenic reactivity reported in this study.

[23] These variables are experimentally (temporally) dependent; see Table 5.

(i.e. via psychophysiological mechanisms of hyperactivity). Thorne's (89) findings are relevant here, since they offer further experimental evidence of the validity of this interpretation. In a series of three handling tests quite similar to Scott's (i.e. Variables 7, 8, 9, 10), Thorne reports two distinct types of "shyness" as follows: (*a*) fearful and eventually submissive to forced handling, and (*b*) excited and refractory to forced handling. It may well be that Thorne's eventually submissive animal would have a stronger Factor A component, and that his other animals would be higher in Factor H.

Billingslea (9) also suggests two factors reflecting "timidity." As has been previously stated, his "freezing" factor appears somewhat related to Factor A, Timidity I. His "timidity" factor seems to be more closely related to Timidity II. It should be pointed out, however, that these comparisons are somewhat speculative, since the only real linkage between Factors A and H and Billingslea's factors are the behavioral indices of freezing, withdrawing, and nonaggressiveness.[24]

[24] The importance of these behavioral indices in the identification of "timidity" factors, however, should not be underestimated. In fact, it should be apparent that the presence of Variables 7 (Avoidance), 8 (Aggressiveness) and 10 (Attraction) on Factors A and H are the major reasons for concluding that the following observation would seem to be very pertinent. Over a period of about 11 months the writer had occasion to make short "weekly visits" to litters of dogs kept in outdoor pens at the Jackson Laboratory. These visits involved picking up each animal individually in order to make certain observations. Certain consistent breed differences in response to these visits became very apparent. For example, cocker spaniels, notoriously responsive to human handing, would playfully tussle and jump in an attempt to be the first to be picked up. Basenjis, while friendly and eager, seemed to exude an air of independence. The most outstanding observation that struck me, however, (and this is the point of the footnote) was this. Not once was I able to pick up a certain slender type of Shetland sheep dog! Their behavior in response to human presence was one of complete avoidance. Regardless of what tricks one could devise (begging, slow approach, offering rewards, etc.) these animals consistently withdrew. This was the only dog breed at the Hamilton Station which demonstrated such extraordinary "timid" behavior. Since there was no reason to believe this extreme "shyness" was due to conditioning, it seems likely it was due to hereditary factors.

On other occasions when it became necessary to actually handle a dog, such as moving a litter to a different pen, it was necessary for several people to team up and "corner" Shetland sheep dogs. When they were finally "captured" they were completely submissive, quite noncombative; in short, they were not aggressive.

It is concluded, therefore, that there is evidence for the existence of at least two "timidity" factors, and it is believed that Factors A and H should help in the eventual clarification as to their underlying nature.

### *Interpretation of Factor J*

Three tests have loadings of .30 or higher on this factor. The relevant variables are:

| | |
|---|---|
| 18. Temperature | +.40 |
| 10. Attraction | +.38 |
| 11. Dominance | +.34 |

This is a factor which is too underdetermined to be properly interpreted. There are only three variables with loadings above .30, and the magnitude of each of these is quite low. There are, however, several speculations which can be offered concerning this partially identified factor.

Temperature indices reflect the ratio of heat production to heat loss in a very gross fashion with respect to the total homeostatic processes of the organisms. Cannon (12) suggests that the temperature indices may be a measure of total metabolism. In fact, he points out that although the significance of temperature indices is quite vague, it is not inconceivable that as an index of metabolic processes such indices represent an expression of thyroid and possible adrenal gland activity. Pointing more toward possible relevance to a "dominance" factor are Mills' recent broad descriptions of the importance of internal and external temperature, wherein he states in part that

". . . a lowered total combustion rate means less energy for thought and action, as well as less

waste heat to be dissipated. Physical and mental characteristics thus change, from the dynamic and pushing, to a more passive let-George-do-it type" (67, p. 276).

The implication of an underlying hormone factor is hinted at in the recent factorial studies of Wenger (103, p. 82), who presents some evidence for a "thyroid" factor. If the variables of Factor J are a part of such a factor, we shall need more biochemical variables in the original correlation matrix to help clarify the underlying structure.

These notions, coupled with the adient picture provided by the projections from Variables 10 (Attraction) and 11 (Dominance), suggest an aspect of emotionality which could be encompassed within the concept of dominance.

### *Interpretation of Factor K*

Three tests have loadings of .30 or higher on this factor. The relevant variables are:

| | |
|---|---|
| 3. Timidity-Confidence III | +.40 |
| 19. Skin Resistance | +.39 |
| 1. Vocalization | +.30 |

This is a factor which is too underdetermined to warrant a guess as to its possible nature. There are only three variables with loadings above .30, and the magnitude of each of these is quite low. In addition, a careful consideration of the significant variables leads to no sensible hypotheses.

### *Findings on Experimental Dependence*

The findings of this section are based on an inspection of Table 2 and have been summarized in Table 5. In situations where there is simultaneous recording of physiological and psychological measures for pairs of variables (viz., Variables 25 and 31, 29 and 32, and 24 and 30), only one of the three potential cases of experimental dependence appears to have shown such dependence—this occurred in the case of Variable 25

TABLE 5

FINDINGS ON APPARENTLY EXPERIMENTALLY DEPENDENT VARIABLES

| Experimental dependence | Type of Apparent Experimental Dependence*: Simultaneous Recording of Psychological and Physiological Measures — Code Number and Name | High Loading on Factor: | Measures Repeated at Varying Intervals of Time — Code Number and Name | High Loading on Factor: |
|---|---|---|---|---|
| Showed experimental dependence | (25) Heart-Rate Change (lights-out bell) | G | (5) Inhibition-Activity III | C |
| | (31) Reactivity (bell) | G | (6) Inhibition-Activity IV | C |
| | | | (3) Timidity-Confidence III | D |
| | | | (4) Timidity-Confidence IV | D |
| | | | (22) Heart-Rate Change III | H |
| | | | (23) Heart-Rate Change IV | H |
| Did not show experimental dependence | (29) Heart-Rate Change (Control-shock) | D | (13) Reactivity I | A, F, G |
| | (32) Reactivity (shock) | F | (14) Reactivity V | B, H |
| | (24) Heart-Rate Change (control-quiet) | B | (15) Heart-Rate Period | E |
| | | | (20) Average Heart Rate | C |
| | (30) Reactivity (control) | F, H | (2) Timidity-Confidence I | E, G, H, |

* None of the apparently experimentally dependent variables showed complete experimental dependence. That is, there were no incidental common factors identified in this battery of tests.

(Heart-Rate Change [bell]) and Variable 31 (Reactivity [bell]). It did not occur in the situations where the stimulation was "control" or "electric shock." Since all three pairs of variables appeared to be experimentally dependent, one wonders why the results occurred as they did. That is, if situations involving bell stimulation contribute to the identification of an incidental common factor, why did the situations involving "shock" and "control" stimulation fail to do so? These particular results actually suggest that none of these pairs of variables (25 and 31, 29 and 32, 24 and 30) is experimentally dependent. According to Table 5, Variables 29 and 32, and Variables 24 and 30 were not experimentally dependent, and Variables 25 and 31 are only two of five variables identifying Factor G (Audiogenic Reactivity). The implication is that the bell stimulation actually operated to produce a legitimate common factor—that is, that there is some underlying psychophysiological process responsible for individual differences in the five test situations which identified Factor G, and that such is not the case in situations involving "control" and "shock" stimulation.

As to experimental dependence due to repeated measures, the following remarks appear to be in order. Apparently experimentally dependent variables which are repeated in successive developmental periods, or which are repeated close together in time (viz., Variables 5 and 6, 3 and 4, and 22 and 23) show experimental dependence.[25] On the other hand, apparently experimentally dependent variables which are repeated with a long interval of time (Variables 13 and 14, and 15 and 20, and the special case of Variable 2, discussed in footnote 25) do not show experimental dependence. That is, the factorial composition of a measure repeated after a long lapse of time does not remain the same. One possible explanation for the shift in factorial composition of a measure taken at different points in time is that the underlying functional processes are affected by developmental and adaptive processes. This notion is particularly suggestive in the case of physiological measures which are homeostatic-regulatory. Whereas in conventional experimental dependence common-factor variance is indeterminately increased, in the case of temporal shifts of the same variable the common-factor variance is indeterminately decreased (and possibly increased again later). Such shifts in the factorial composition of a given variable might appropriately be referred to as "temporal dependence."

The conclusions drawn here can only be regarded as suggestive. The major point of this section has been to point to some evidence which suggests that there are real problems involved with respect to the concept of experimental dependence in animal behavior studies,

[25] The only exception to this occurred in the case of Variable 2 (Timidity-Confidence I). This variable was administered during Scott's "critical" period, the fifth week in the development of the dog. Variables 3 and 4 were given in the "socialization" and "juvenile" periods and showed experimental dependence; Variable 2 did not. It may well be that the shift in factorial content of the Timidity-Confidence measure is tied up with the fact that this shift occurred some time between the fifth (the "critical" period) and subsequent weeks in the social development of the pup. The implication is that very rapid developmental changes occur during the fifth week and that the functional significance of the Timidity-Confidence measure changes coincident with the changes within the organism. This is consistent with the interpretation given to changes in factorial composition which occur in the case of repeated measures having long intervals of time.

and that we need experimental studies devoted specifically to these problems.

### *Discussion*

Despite the force of such works as Skinner's *Behavior of Organisms* and other "hollow organism" proponents, the contributions of such physiological and comparative psychologists as Lashley, Jacobsen, Hebb, Morgan, Beach, Darrow, Tryon, etc., and more recently the global attempts of Wenger (103), Halstead (43), and particularly G. L. Freeman (30), are too pertinent to the central problems of psychology to be cast off as unimportant offshoots. Although most psychologists agree that psychology is the science of the behavior of organisms, there is a tendency on the part of many of them to throw the organism entirely out of the picture. The strongest case for retaining the organism has come from the physiologists; in the field of emotion, perhaps the most relevant contributions have come from the work of Cannon (12) on homeostasis. Although psychologists have been aware of the nature of Cannon's contributions, and have attempted to incorporate them into the experimental domain of certain psychophysiological problems, the only major work which has attempted a complete theoretical integration of homeostatic principles within psychology is Freeman's book. Perhaps Freeman's position is most clearly indicated when he states:

> . . . the key to the dynamics of total behavior is to be found more in the complicated energy exchanges going on within the body tissues than in the work of outside energies acting upon them. It has long been recognized that external changes, such as the air vibrations exciting the auditory nerve, serve mainly as "trigger" charges to release food energies already stored in the body tissue. Furthermore, the organismic energy system is not excited by external energy changes unrelated to its internal needs (30, p. 49).

By carefully compiling a battery of tests which includes psychological, social, and physiological variables, and by subjecting these variables to a factorial analysis, it was the hope of this study to identify some of the parameters involving organismic energy transformations. Some success in this endeavor seems to have been achieved. While the interpretable factors have been named, it should be pointed out that *each of these conceptualizations is based only on the measures of this particular test battery,* and that such conceptualizations must be regarded as no more than hypotheses for further factorial and experimental exploration. Perhaps the most striking over-all statement which can be made about the factors of this investigation is that *they all involve both psychological and physiological measures.* It should be apparent that one of the reasons for obtaining such "psychophysiological functional unities" is the fact that the psychological and social measures (as well as the physiological measures) are all based on observed behavior. In addition, we cannot minimize the often repeated but sometimes forgotten fact that when dealing with animals the investigator has considerable control over his subjects. It is often not possible to gain as good control when dealing with human subjects, particularly when working in the domain of emotionality.

If the causal relations between genes, bodily factors (brain structure, endocrine constitution, cardiovascular apparatus), and behavior are to be eventually discovered it seems to the writer that the first job of the psychologist is to identify behavioral "phenotypes" which have enough stability and potential psychobiological "reality" to justify the time and energy which will have to be expended

in order to determine the "genotypes." Although the developmental sequence is from gene to biological mechanism to behavior, the best way to attack this problem is in reverse, that is, from behavior to biological mechanism to gene. No geneticist has ever been able to determine the underlying genotype without some very definite notions about the phenotype. It is believed that the factorial approach may be the psychological methodology which can give us behavioral "phenotypes" (73, 74). It should be made clear that there is no claim made here that different "emotions" are being identified, although it is not inconceivable that once all the factors of emotionality are known, various combinations of the components of emotionality may provide a description of different "emotions." While the question of whether the factors of this study are constitutional or environmental cannot be answered at this time, it should be pointed out that there is some evidence from other types of investigations that there might be an hereditary component in the case of Timidity I and II (90), Aggressiveness (62), Activity Level (93), and Audiogenic Reactivity (42). It is expected that subsequent studies will show that some of these factors are quite subject to environmental "conditioning" (e.g., possibly Factor B, Heart Reactivity to Social Stimulation), while others are simply "set off" by environmental stimulation (e.g., Factor G, Audiogenic Reactivity).

### *Problems for Further Investigation*[28]

Perhaps the most obvious statement to be made about problems for future investigation relates to the necessity for establishing the stability of factorial findings. This has been termed factorial invariance, and in explorations of a new domain factor analysts accept "configurational invariance" as opposed to "numerical invariance" as a sufficient demonstration of the stability of a given factor. The factors of this study, therefore, need to the reaffirmed in future factorial studies of animal behavior.

In addition to the general problem of factorial invariance, the test coverage of the emotionality domain must be extended, particularly on the physiological side of the picture. We need a much wider sampling of autonomic measures under energy-displacing conditions. Such measures as respiration rate, respiration amplitude, electroencephalographic measures, physiological measures of unrestrained animals, blood sugar content, saliva analysis, gastrointestinal activity, size of endocrine glands, glandular activity, etc. need to be included in subsequent factorial studies of animal emotionality. In particular, various biochemical indices need to be included because of the growing body of evidence for structural and functional differences of the biochemical constitution of adjusted and maladjusted organisms.

On the behavioral side we need more "stress" tests, similar to the Caged Dog test (79), and Fredericson's (28) interesting variation of this test. The concept of "frustration tolerance" has shown itself to be quite useful in human testing, and the early investigations of Pavlov (68), Maier (63), Gantt (38), and Masserman (64) on "experimental neurosis" in animals is strong argument for including "upper limit" measures of this kind in order to get at more of the underlying factors of emotionality.

Another highly provocative area of research will be in the interrelationships between emotionality measures and mental ability measures (i.e., learning and problem solving). Such a study should be of considerable help in untangling the

[28] Comparative psychologists have been somewhat lax in animal testing studies in that they have failed to give proper consideration to certain basic principles of test construction. For example, with the exception of the studies of a few investigators such as Carr, Hunter, Lashley, Spence, Stone, Tolman, and Tryon, experimental reports in animal behavior do not even mention the term reliability. It is time more consideration was given to adapting mental test theory to problems in animal testing. This study is no exception to the typical state of affairs in that no reliability data are available for any of the variables of this test battery. Because of the important relationship between test reliability and test "communality" (see L. L. Thurstone, *Multiple-Factor Analysis* [91, p. 84]), future factorial studies involving tests from this battery should include information concerning the reliability of these measures.

confusion which surrounds our interpretations of the relationship between the control and expression of the emotions. That important findings are imminent in this domain is obvious in the recent attempts of Darrow (17, 18) to demonstrate relationships between brain-wave patterns and autonomic activity. Furthermore, Darrow's concept of emotion as "functional decortication" (15) is a gem of insightful psychologizing which has the wide applicability of many of the Freudian concepts, as well as an important body of experimental findings to back it up. The factors of the present study are probably "peripheral" factors; the factors of mental ability are probably "central" factors. It is not inconceivable that a global factorial attack on the interrelationships of both of these domains with properly "loaded" variables will provide us with some new insights. The recent (nonfactorial) study of Searle (82), for example, points up the very great importance of motivational and emotional "factors" in the learning performances of Tryon's "maze-bright" and "maze-dull" rats.

The analysis of factor scores of groups of dogs in various combinations of emotionality factors should be extremely interesting in terms of psychosomatic syndromes. This kind of analysis, combined with "stress" testing, should be illuminating. As an example, consider one group of dogs with high scores on Factors A and B (i.e. Timidity I and Heart Reactivity to Social Stimulation) versus another group with low scores on these factors. How would these organisms react to environmental stress? Would one group develop ulcers and the other a "situational" neurosis? There are many experimental problems of this nature which could follow factorial studies of animal behavior (73).

In addition to pointing up further factorial studies, this investigation has turned up several other smaller projects which should be pursued. These will be mentioned very briefly. (*a*) More detailed "wave" analyses of "vocalizations" (Variable 1) should be pursued after the manner of Seashore's pioneer phonophotographic studies. A more thorough analysis of wave patterns should clarify our interpretation of the Timidity I factor. (*b*) The direction of heart-rate change to social stimulation appears to be quite unpredictable. Investigations are needed which will introduce greater control over the stimulus conditions and the temporal conditions in the sequence of situational changes, so that physiological "effect" can be directly related to psychological "cause." (*c*) Studies of skin resistance level and psychogalvanic response should be carried out on the dog. Since it is known that the sweat glands of dogs are confined to certain surface areas (e.g., primarily the foot pads, 12, 23), such an experiment would be a crucial test for the secretory theory of the galvanic skin response (66). (*d*) In the light of the projections of systolic blood pressure (Variable 17) and temperature (Variable 18) on Factor G (Audiogenic Reactivity), comparisons should be made of the blood and temperature characteristics of "audiogenic" versus "nonaudiogenic" strains of rats and mice. The hunch is that the "audiogenic" strains will have significantly higher blood pressure and temperature readings, and that such constitutional differences may lead to a detailed description of the possible cardiovascular mechanisms underlying audiogenic seizures.

The relevance of "obverse factor analysis" (85, 86) in factorial-genetic studies should not be overlooked. Since, in the obverse analysis, we correlate individuals instead of tests it should be obvious that if the genes are behind our psychological and psychophysiological factors, we should expect dogs of the same breed to correlate more among themselves than with other breeds. The extent to which this is true will vary, of course, according to the degree of genetic homogeneity (i.e., the coefficient of inbreeding) of the several breeds. This approach to the problem is extremely provocative, and, in fact, for genetic studies, may be even more fruitful than the traditional factor methods.

## *Summary and Conclusions*

The Division of Behavior Studies of the Roscoe B. Jackson Memorial Laboratory has been conducting a long-range program on the relationship between genetics and behavior in mammals (especially dogs). The dog project is being carried out in three basic stages: (*a*) test development, (*b*) factorial analyses of the basic data, and (*c*) genetic analyses. Current plans include doing separate factorial anlyses of the social-emotional (emotionality) domain and mental ability domain, and eventually doing an over-all analysis of the two areas combined. Since the data-gathering of the first five years has been primarily in the emotionality domain, a factorial study in this area is pertinent at this time.

The sample of this study consists of 53 pedigreed dogs distributed as follows: 8 Basenjis, 6 beagles, 12 cocker spaniels,

5 Scotch terriers, 8 Shetland sheep dogs, 14 wire-haired fox terriers.

The test battery provided 32 physiological, psychological, and social measures. Pearson product-moment correlations between the measures were computed by means of IBM tabulating equipment. The test scores were first transformed to normalized standard scores and then coded to single digits for use in computing the intercorrelations.

Ten factors were extracted from the correlation matrix by means of Thurstone's centroid method. The communality estimates were made by entering the highest correlation in the column in the original and subsequent residual matrices. The tenth-factor residuals ranged from minus .14 to plus .11, with a standard deviation of .0448.

The 10 factors were next rotated to an oblique configuration in accordance with the concept of simple structure. The correlations between the 10 factors were determined.

The factors were tentatively interpreted as follows: Factor A, or Timidity I, is regarded as a psychophysiological factor characterized psychologically by freezing and internally by liberation of aroused energy via physiological mechanisms. Factor B, or Heart Reactivity to Social Stimulation, is regarded as a psychophysiological factor dominated by heart-rate changes in social situations. Factor D, or Aggressiveness, is primarily a psychological factor characterized behaviorally by agitated hyperactivity in response to social and inhibitory stimulation. Factor F, or Activity Level, is primarily a psychological factor characterized by activity indices in a wide variety of situations. Factor G, or Audiogenic Reactivity, is a psychophysiological factor characterized psychologically and physiologically by very acute reactivity to auditory stimulation. Factor H, or Timidity II, is regarded as essentially a psychological factor of timidity characterized by withdrawal and hyperactivity. Factors C, E, J, and K are underdetermined and have not been interpreted.

As a secondary interest, certain problems relevant to experimental dependence were discussed and demonstrated. The following conclusions were tentatively suggested: (*a*) Apparently experimentally dependent variables involving simultaneous recording of two different levels of observation (i.e., psychological and physiological) do not necessarily identify incidental common factors. (*b*) Apparently experimentally dependent variables that are repeated with long intervening periods of time (i.e., that permit of developmental and/or adaptation effects) do not necessarily identify incidental common factors. (*c*) Apparently experimentally dependent variables that are repeated with short intervening periods of time (i.e., that do not permit of developmental and/or adaptation effects) demonstrate partial experimental dependence. (*d*) Apparently experimentally dependent variables that involve a "critical" period in the development of the organism (i.e., that permit of very rapid change in a very short period of time such as one week) do not necessarily identify incidental common factors. (*e*) None of the apparently experimentally dependent variables of this study showed complete experimental dependence (i.e., there were no incidental common factors identified in this battery of tests). It was recommended that because of test administration problems peculiar to animal behavior, experimental investigations of experimental dependence should be carried out.

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